

Response to Comments – Hydrogeologic Evaluation of Proposed Leque Island Restoration by Pacific Groundwater Group – 07/09/2013

EPA received a number of the very detailed comments on PPG's study regarding such areas as hydraulic head levels, salinity measurements, and interpretation of data. EPA believes this level of detailed comments can only be responded to appropriately by the author of the study and so those comments should be directed to PGG. However, it is appropriate for EPA to respond to some key comments. A summary of those comments and EPA's responses are listed below.

Commenter's Organization & Date of Letter	General Comment	Response
Washington Waterfowl Association - (Summarized from 01/25/2013 memo)	1. The PGG study didn't use realistic and/or measured parameters in the model.	More precise site specific data is not likely to change the predicted direction of groundwater flow from Camano Island towards Leque Island; nor that the ditched Camano Island lowland (monitoring site) is a predicted discharge area.
	2. A groundwater study was conducted, but essentially none of the groundwater model inputs were measured for Leque Island.	Additional site-specific data may result in improved model performance, but the incremental gains will be local and are unlikely to alter the predicted flow direction from Camano Island towards low lands (Davis slough and Leque Island).
	3. The study results show there will be high salinity GW flow into the legally-protected dedicated Island County Sole Source DW aquifer and Juniper beach water district drinking Water Recharge area.	EPA does not concur with this conclusion. After restoration, the model does predict groundwater flow in the direction from Leque Island toward Davis Slough, but (on average) <u>all</u> groundwaters flowing through this local area are predicted to be discharged somewhere along the ditched Camano Island lowland. We do not conclude that high salinity water will flow across the monitoring site and into the identified aquifer.
	4. The groundwater study/model is temporally static, and does not consider long term changes in Leque Island groundwater levels, seasonal variation, sea level rise, and groundwater salinity as a result of the proposed restoration.	The groundwater model was set up to evaluate on annually-averaged basis the impact on groundwater flow direction after the restoration project was completed. The potential impact of higher groundwater water levels at Leque Island has been addressed by PGG using supplemental model runs, which predict Leque Island head values would need to range from 3.1 to 7.1 feet above current estimate of post-restoration heads to cause significant regional reversals of flow. These groundwater head increments would be highly unlikely to occur year around. To address potential

Commenter's Organization & Date of Letter	General Comment	Response
		seasonal effects, the model may be run on a seasonal basis. However, on an annual average, model results indicate no flow reversal at east Camano Island, except from Leque Island toward Davis slough, thus no threat of salt water intrusion to the west of the monitoring site.
	5. The study does not meet the original EPA study design requirements.	EPA's review concludes that the study did meet the design parameters provided by the agency.
	6. Assumptions for the groundwater salinity and elevations/flow are not conservative enough to represent actual conditions.	The developed model is a groundwater flow model and does not simulate salinity. Model outputs therefore are not influenced by any assumptions on salinity. Conditions simulated by the model represent expected actual conditions. Conservative scenarios have been investigated by PGG in supplemental model runs.
	7. Regardless of use of non-conservative model input conditions and lack of consideration of long-term changes on a restored Leque Island, the groundwater model still shows groundwater flow into the protected Sole Source Drinking Water Aquifer from Leque Island.	This is not the conclusion that EPA reached from a review of the data. The groundwater model predicts that post-restoration flow is from Leque Island toward the monitoring site as a discharge area.
Washington Waterfowl Association (06/06/2013)	1. The nearby Juniper Beach Water District (JBWD) well has a groundwater elevation that is only 3.5 inches above the lowest modeled groundwater elevation, but is up to 1.4 ft below the study test wells in the Camano and Leque lowlands, and at a minimum shows the modeled groundwater elevation between the McIntyre and Oksendahl wells may be nearly a foot higher than actual.	This comment is better addressed by PPG since they know the context of measured water levels at various wells and pumping conditions at Juniper Beach. However, it should be noted that the model simulates annual average groundwater head values; therefore, one should expect variations relative to synoptic wells' measurements. If indeed the purported well groundwater elevation is representative of annual average conditions throughout the Juniper Beach area, then a model run using commensurate, concurrent pumping rates can be conducted.
	2. Siltation will eliminate drainage channels on Leque Island and over time Leque Island and Davis Slough will relatively rapidly silt in, eventually to approximately 13 ft (mllw; approximately 11 ft NAVD88). Thus, eventually, the groundwater level underlying Leque Island will likely rise to some level between current levels and mean higher high water (between 7 ft and 13 ft NAVD88). Davis Slough has already been cut off from Port Susan by siltation over the past 30 years, and has silted in considerably along several hundred feet of its southern extent.	The Battelle Hydrodynamic model estimates that the bottom shear stress distribution in the restoration site is smaller than the critical shear stress value of 0.1 Pa for erosion to occur during most of tidal cycle. While this indicates potential toward a depositional environment, additional model runs can address the impact on groundwater levels if the drainage ditches are not formed as expected or with much less drainage efficiency.

Commenter's Organization & Date of Letter	General Comment	Response
	3. Future drawdown of the aquifer underlying the Camano “upland” has not been adequately addressed considering full build out of the JBWD system as well as other properties that may be developed with private wells.	The overall potential to lower the groundwater level on Camano Island through additional ‘build-out’ and future pumping remains a significant threat to the sustainability of this aquifer. These risks are independent of the proposed restoration actions at Leque.
	4. Average recharge reported for north Camano Island by Sumioka and Bauer (2004) was 3.51 inches for north Camano Island, which may be a high estimate for Aquifer D in the NE Camano Island region as the glacial till underlying the shallower Aquifers A, B, or C (between the ground surface and Aquifer D) may preferentially direct groundwater radially to the edges of NE Camano Island, thus reducing Aquifer E recharge. Using the “Island wide” estimate of approximately 4 inches per year is not appropriate because of the unique geological formation underlying NE Camano Island.	Figure 3-9 shows aquifers B and C as the deeper aquifers and not as the shallower aquifers. The figure shows aquifer E as the top confined aquifer. The said recharge value was applied to the top unconfined layer and not directly to aquifer D. Refer to page C-3 of Appendix C. This is a sound modeling approach as MODFLOW computes horizontal flow and vertical leakage as a function of the horizontal and vertical hydraulic conductivity of each aquifer, and the vertical conductivity and thickness of any of the intervening semi-pervious layers (aquitards).
	5. Use of only one well located just inside a dike and next to a ditch to determine upward groundwater gradients in the Camano lowlands.	More precise site specific data are not likely to change the predicted direction of groundwater flow from Camano Island towards Leque Island; nor that the ditched Camano Island lowland (monitoring site) is a predicted discharge area.
	6. Use by PGG of highly overestimated hydraulic conductivity underlying Camano Island in order to get the model to calibrate.	This can be addressed by additional model runs. However, more precise site specific data are not likely to change the predicted direction of groundwater flow from Camano Island towards Leque Island; nor that the ditched Camano Island lowland (monitoring site) is a predicted discharge area.
Associated Earth Sciences, Inc. Technical Memorandum (02/12/2013)	1. The PGG study scope was limited and did not include site specific data, and based on regional data.	Site specific data always improves accuracy. EPA would suggest that JBWA provide its data to Fish and Wildlife and Ducks Unlimited. Additional model runs can use site specific data for refinement, which could assist with design of specific management actions. However, more precise site specific data are not likely to change the predicted direction of groundwater flow from Camano Island towards Leque Island; nor that the ditched Camano Island lowland (monitoring site) is a predicted discharge area.

Commenter's Organization & Date of Letter	General Comment	Response
	2. Request that a new study be developed using additional site specific information and water use information already developed by others.	EPA does not believe that a new study is needed in order to make its determination regarding the impact of the salmon restoration project. EPA does believe that Island County could benefit from close monitoring of salt water intrusion as a result of a number factors including additional pumping to meet future growth.
	3. Request that EPA require WDFW to complete a detailed hydrogeologic evaluation of Leque Island and the northeastern portion of Camano Island to address these concerns.	This has been addressed through uncertainty analysis. If a detailed hydrogeologic evaluation of Leque Island was completed, it is still highly unlikely that PGG findings would be altered.
	4. The assumption that “pumping on the island is assumed to be largely non-consumptive due to septic effluent returns” might be dubious and the annual average 9 gpm withdrawal from a single well might be lower than actual annual rates.	EPA agrees that the assumption “pumping on the island is assumed to be largely non-consumptive due to septic effluent returns” might be dubious and the annual average 9 gpm withdrawal from a single well might be lower than actual annual rates. Additional model runs with increasingly more accurate pumping withdrawals can be carried to further refine risk analysis and project design scenarios. However, EPA does not believe that moderate adjustments to these input parameters would change the overall direction of groundwater flow.
	5. Under the restored condition, 365 in/yr of recharge of brackish water due to tidal inundation may increase groundwater salinity, especially if the purported high drainage efficiency of newly formed channels does not materialize.	This may be true, but the magnitude of groundwater salinity is irrelevant to the issue of groundwater flow directions.
	6. A longer pump test analysis should have been conducted as opposed to the single and short duration pump test carried in this study.	More and longer pump test analysis could have been conducted as opposed to the single and short duration pump test carried in this study to increase accuracy. However, model calibration using accurately measured water levels and inferences from soil texture is a valid approach to estimate unknown parameters. Certainly, the use of pump-test inferred hydraulic conductivity values would have minimized model uncertainty. Aquifer properties estimated by pump tests will improve model calibration locally, but EPA does not expect that the incremental gains to alter conclusions about flow directions.
Camano Water Systems Association	1. PGG has demonstrated in this evaluation (<i>Section 5.3 & Figure 5.3</i>) illustrating the influence of seawater contamination as tide water twice each day infiltrates Aquifer D.	This is not the conclusion that EPA reached from a review of the PGG assessment. The groundwater flow will remain in the general direction from Camano Island towards the ditched Camano Island lowland and

Commenter's Organization & Date of Letter	General Comment	Response
(02/12/2013)		Davis Slough is the general discharge area.
Snohomish County Farm Bureau (01/24/2013)	1. The feature of this study that we find of the greatest significance is that it very plainly shows the westward movement of saltwater into the aquifer.	The model does not simulate saltwater movement. This is not the conclusion that EPA reached from a review of the PGG assessment. Figure 5.3 shows that groundwater flow will remain in the general direction from Camano Island towards the ditched Camano Island lowland (monitoring site). The monitoring site is predicted to be the general area of discharge.
Water Resources Program, Washington Department of Ecology (01/16/2013)	1. On Camano Island, the highest ground water elevations are found near the center of the northeastern portion of the island. Groundwater generally flows from these higher areas in the center of the island towards shorelines where it discharges into saltwater. The area between the mainland and Camano Island is a convergent discharge area of groundwater from both Camano Island and the mainland.	This is consistent with EPA's interpretation of the assessment.
	2. The sea level aquifer on Camano discharges to the north, south and east – toward Leque Island. Removing dikes on Leque will have no effect on the aquifers of Camano Island. Periodic tidal inundation should periodically lessen the freshwater discharge so it may back up the groundwater head and retain more freshwater in the aquifer.	EPA concurs with Ecology's review findings.
	3. Stillaguamish River water will also dilute any salinity tidal effect.	Figure 3-2 from the PGG assessment predicts only moderate salinities in the area just offshore of Leque Island during high tides.
	4. ECY concurs with the PGG's model conclusions as follows: ➤ Increased groundwater levels beneath Leque will not cause a reversal of groundwater flow directions in the eastern edge of Camano Island. The model predicts that post-restoration groundwater flow will remain in the direction from Camano Island towards the Leque lowlands. Continued flow in this direction means that brackish groundwater below Leque would not migrate to aquifers beneath Camano. ➤ Groundwater level changes on Camano due to the Leque	EPA agrees with the noted findings of Ecology's review of the PGG assessment.

Commenter's Organization & Date of Letter	General Comment	Response
	<p>Island restoration will be less than .1 feet. This slight increase in the groundwater head should result in reduced potential for salt-water intrusion based on established density relationships with the freshwater lens floating above the salt water interface.</p> <p>➤ Post restoration groundwater salinities on Leque Island are expected to show little change from current salinities.</p>	